



## Diversity of spiders in coffee agro-ecosystem of Western Ghats in Karnataka, India

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### Abstract

Spiders survey study was conducted in coffee agro-ecosystems of Muthodi and Chikholale and residential area of Chikmagaluru town for six months from January- June 2019. Altogether 105 individuals representing 12 families and 30 species were documented. Among them 8 families from Muthodi coffee agroecosystem, 6 families from Chikholale coffee agroecosystem, out of them 5 families were same. In Residential area 7 families were documented, out which 4 families are same as coffee agroecosystem and 3 families are different i.e., Agelenidae, Sparassidae and Hersilidae families. Spiders of 12 families were divided into eight functional groups (guilds) based on their foraging behavior in the field. The most dominant guild was the orb weavers (45%) comprised of 13 species representing 5 families, among them family Araneidae representing 11 species.

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## Introduction

Spiders are the most-diverse and abundant invertebrate predators in terrestrial ecosystems (Wise 1993, Nyffeler 2000), foraging primarily on insects. Because of their high abundance and insectivorous foraging, spiders are considered the major agent controlling insect communities in terrestrial ecosystems (Riechert and Lockley 1984, Nyffeler and Benz 1987, Marc *et al.*, 1999, Nyffeler 2000). These characteristics make spiders a good indicator for comparing the biodiversity of various environments and for assessing the effects of disturbances on biodiversity (Clauseu 1986, Churchill 1998, Topping and Lövei 1997, Maelfait and Hendrickx 1998, Marc *et al.*, 1999, Riecken 1999). An extensive literature on biodiversity in coffee farms indicates that coffee systems with high shade cover and tree diversity support higher species richness of associated (or wild) biodiversity than coffee systems that are structurally less diverse (Lin and Perfecto 2012). However, spiders seem to be an exception to what has been found for other taxa. Studies examining spider diversity on coffee plants have found that accumulated spider richness does not differ between the most and least intensified systems (Marin and Perfecto 2013), but that local spider abundance is higher in the most coffee plantations (Pinkus-Rendonet *et al.*, 2006, Marin and Perfecto 2013).

Spiders are ubiquitous predators that are abundant and diverse in agricultural ecosystems. Spider assemblages have the ability to limit population growth of arthropod pests alone or in combination with other natural enemies (Mansour *et al.*, 1980; Orazé and Grigarick 1989; Riechert and Bishop 1990; Carter and Rypstra 1995).

The current global list of spider fauna is approximately 42,055 belonging to 3821 genera and 110 families (Platnick, 2011). The spider fauna of India is represented by 1520 spider species belonging to 377 genera and 60 families (Sebastian and Peter, 2009). There still exist major gaps in our knowledge of the biodiversity of spiders in many areas within varied ecosystems of India. Pocock, described 112 new species of spiders from India.

British India and is referred and still referring by arachnologist of India. Tikader (1987) also published the first comprehensive list of Indian spiders, which included 1067 species belonging to 249 genera in 43 families

The pioneering contribution on the taxonomy of Indian spiders is that of European arachnologist Stoliczka (1869). Review of available literature reveals that the earliest contribution by Blackwall (1867); Karsch (1873); Simon (1887); Thorell (1895) and Pocock (1900) were the pioneer workers of Indian spiders. Tikader (1980, 1982), Tikader, and Malhotra (1980) described spiders from India. Tikader (1980) compiled a book on Thomisid spiders of India, comprising two subfamilies, 25 genera and 115 species. Of these, 23 species were new to science. Descriptions, illustrations and distributions of all species were given. Keys to the subfamilies, genera, and species were provided. Tikader and Biswas (1981) studied 15 families, 47 genera and 99 species from Calcutta and surrounding areas with illustrations and descriptions.

The knowledge on diversity and distribution of spiders of Western Ghats of Karnataka is sparse compared to other parts of Western Ghats and different habitats. The need is, in fact made all the more urgent by the spirit of developmental activities, new settlements also affected the natural habitat for spiders. The present study aims to carry out the work on distribution of spider species with their guild structure in three selected locations of Chikmagalur district.

## Materials and methods

### Study area

The study was conducted in coffee agro-ecosystems of Muthodi and Chikhole and residential area of Chikmagalur town. Chikmagalur is located in the foothills of Mullayangiri range, the highest peak between Himalayas and the Nilgiris, in the shadow of the Western Ghats. Chikmagalur is famous for coffee production and hills stations there and is known as "Coffee Land" of Karnataka. It is a place in India where coffee was cultivated for the first time. The field observations and collection of spiders were made from January to June 2019.

### Descriptions of the habitats

In this study area two type's habitats were selected. The 1<sup>st</sup> habitat type is coffee agroecosystem, most of the mountainous areas with coffee plantations. 2<sup>nd</sup> habitat type is residential area.

### Muthodi Coffee agroecosystem

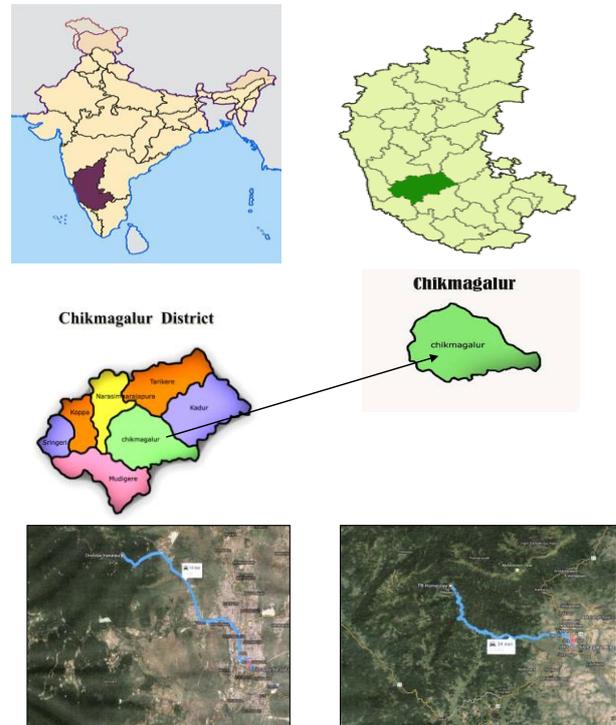
Muthodi belonging to Bhadra Wildlife Sanctuary, having the lush green vegetation of mostly moist and dry deciduous forests, which is located at a distance of 44km from Chikmagalur. More than 120 tree species grow here, which include Teak, Rosewood, Mathi, Honne, Nandi, Tadasalu and Kindal. Besides being the perfect haven for tigers, the Bhadra sanctuary plays host to exotic animal species. The elephant, gaur, tiger, panther, sambar, spotted deer, mouse deer, barking deer, sloth bear, wild boar, wild dog, mongoose, porcupine, jackal, and the common langur are some of the mammals found here. Among birds the black winged kite, king vulture, great horned owl, great pied hornbill, Indian tree pie, black napped flycatcher and the open billed stork were common. The temperature of the region being 22-32°C, the area where the survey was conducted consists of both Arabica and Robusta coffee plantations, with the addition of some of the economically important plants.

### Chikholale coffee agroecosystem

Chikholale is a sub village in Hirekolale Village in Chikmagalur taluk in Chikmagalur District. It is located 9 KM towards west of Chikmagalur. The most of the flora of this area are silver, Arabica coffee, jack fruit trees and some economically important plants and trees.

Residential Area of Chikmagalur Chikmagalur is located between 12°54'42" and 13°53'53" North latitude and between 75°04'46" and 76°21'50" East latitude. Its greatest length from east to west is 138.4km and from north to south is 88.5km. It is located at an elevation of 3,400 feet. The temperature of city ranges between 11-20°C during winter and 25-34°C during summer. The city receives an average rainfall of 1925mm/year. Chikmagalur district is surrounded by

Chandra Drona hill range and dense forest, about 30% of the district area is covered by forest.



**Fig. 4.** Map showing study area of Chikmagalur.

### Collection techniques

Collection of spiders to study their diversity in their natural environment includes variety of techniques and methods which involves; visual search technique, beating or inverted umbrella technique, active searching, net sweeping, leaf litter sampling, pitfall trap and hand picking method. Among all this techniques, the techniques which we had used for spider collection was hand picking method.

### Hand picking method

This method is one of the best methods for collection of spiders in any environment. A soft paint brush or small twig was used to gently knock the specimen into the zip covers or small plastic vials. The specimens were carefully picked up by hand turning the wood logs or leaf litters. By this method very small spiders can also be collected which can get escaped while collecting using soft brushes or twigs. Then the collected specimens were brought to the laboratory, their photographs were taken and were stored in 2% formalin in small plastic vials.

The freshly collected individuals were etherized with chloroform, then placed on a white paper and photographed immediately. All spider specimens were identified using the taxonomic keys for Indian spiders by Sabestian and Peter (2009) and using the websites www.southIndianspiders.com.

After taking the photograph each individuals were preserved in separate plastic bottles in 2% formalin solution. Then, preserved specimens were deposited in Museum, Department of Applied Zoology, IDSG Government College, Chikmagalur.

**Result and disscussion**

Chikmagalur taluk provides diverse habitat to various spider’s species. A total of 105 spider individuals were collected in the study period from Residential area, Muthodi and Chikholale coffee estates of Chikmagalur. Among 105 individuals, 30 species representing 14 families were documented.

*Distribution of spider family in coffee agroecosystem*

Present study was carried out to document the diversity of spiders in two locations of coffee agroecosystem in Chikmagalur.

**Table 1.** Distribution of spider species in three selected locations of Chikmagalur district.

SL	Species Name	Family	Muthodi	Chikholale	Residential Area
1	<i>Argiope pulchella</i> (Thorell, 1881)		+	-	-
2	<i>Gasteracantha geminata</i> (Fabricius, 1798)		+	-	-
3	<i>Argiope</i> sp. (Audouin, 1826 )		+	-	-
4	<i>Neoscona nautica</i> (L. Koch, 1875)		+	+	-
5	<i>Neoscona mukerjei</i> (Tikader, 1980)		+	-	-
6	<i>Cyclosa</i> sp. (Menge, 1866)		+	+	-
7	<i>Cyrtophora citricola</i> (Forsskål, 1775)	Araneidae	-	-	+
8	<i>Cyrtophora</i> sp. Simon, 1864		-	-	+
9	<i>Nephila pilipes</i> (Fabricius, 1793)		+	-	-
10	<i>Herennia multipuncta</i> (Doleschall, 1859)		+	-	-
11	<i>Hypsosinga</i> sp. (Ausserer, 1871)		+	+	-
12	<i>Aelurillus</i> sp. (Simon, 1884)		+	+	+
13	<i>Plexippus phyllus</i> (Karsch, 1878)		+	-	+
14	<i>Plexippus</i> sp. (Koch, 1846)	Salticidae	+	-	-
15	<i>Oxyopes shweta</i> (Tikader, 1970)		+	+	-
16	<i>Oxyopes</i> sp. (Latreille, 1804)	Oxyopidae	+	+	-
17	<i>Pholcus fragillimus</i> (Strand, 1907)		+	-	-
18	<i>Pholcidae</i> spp.		+	+	-
19	<i>Crossoprizalyoni</i> (Blackwall, 1867)	Pholcidae	-	-	+
20	<i>Scytodes</i> sp. Latreille, 1804	Scytodidae	+	-	-
21	<i>Theridion manjithar</i> (Tikader, 1970)		+	+	-
22	<i>Argyrodes</i> sp. (Simon, 1864)		-	+	-
23	<i>Steatoda</i> sp. (Sundevall, 1833)	Theridiidae	-	+	-
24	<i>Achaearanea</i> sp. 1 (Strand, 1929)		-	-	+
25	<i>Annandaliella travancorica</i> (Hirst, 1909)	Theraposidae	+	-	-
26	<i>Perenethis venusta</i> (Koch, 1878)	Pisauridae	+	-	-
27	<i>Lepthyphantes</i> sp. (Menge, 1866)	Linyphiidae	-	+	-
28	<i>Tegenaria domestica</i> (Clerck, 1757)	Agelenidae	-	-	+
29	<i>Hersilia savignyi</i> (Lucas, 1836)	Hersilidae	-	-	+
30	<i>Heteropoda venatoria</i> (Linnaeus, 1767)	Sparassidae	-	-	+

+: Present, -: Absent

*Percentage distribution of Spiders on the basis of their family*

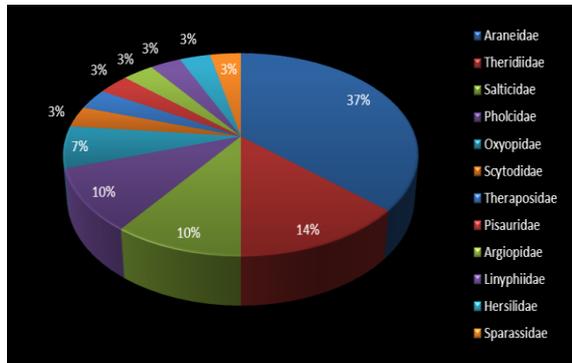
A total of 12 families were documented in the study period (Table 1). Among them family Araneidae is the most dominant representing 37%of the families, followed by family Theridiidae representing 14% of the families, families Salticidae and Pholcidae

representing 10% of the families respectively, families and Oxyopidae representing 7% of the families respectively, families Scytodidae,

Theraposidae, Pisauridae, Linyphiidae, Agelenidae, Hersilidae and Sparassidae representing 3% of the families respectively (Fig. 1).

*Muthodi coffee agroecosystem*

In this study area totally 20 species, belonging to 08 families were recorded (Table 1). Among them 9 species belonging to the family Araneidae, followed by 3 species belonging family Salticidae, 2 species belonging to the family Oxyopidae, 1 species belonging to the families- Pholcidae, Scytodidae, Theridiidae, Theraposidae, Pisauridae each. Among these, the family Araneidae is most dominant it includes 30% (graph should change) of the species, followed by Salticidae is the second dominant family representing 15% of the species, Oxyopidae representing 10% of the species and Pholcidae, Scytodidae, Theridiidae, Theraposidae, Pisauridae, representing 5% each of the total species diversity.



**Fig. 1.** Percentage wise distribution of spider families.

*Distribution of spider species in different locations*

Totally 30 species representing 12 families were documented in all three locations of Chikmagalur taluk. Among them, *Aelurillus* sp. representing the family Salticidae is common in all three of the location. The species which were common in both the coffee agroecosystem includes *Neoscona nautical*, *Hypsosinga* spp. and *Cyclosa* spp. representing

Araneidae family, followed by *Oxyopes shweta* and *Oxyopes* spp. representing the family Oxyopidae, *Pholcidae* spp. representing Pholcidae family, *Theridion manjithar* representing Theridiidae family. The species *Plexippus paykulli* representing Salticidae family which is common in Muthodi coffee agroecosystem and residential area (Table 1).

*Spider species with their common name and their guild structure*

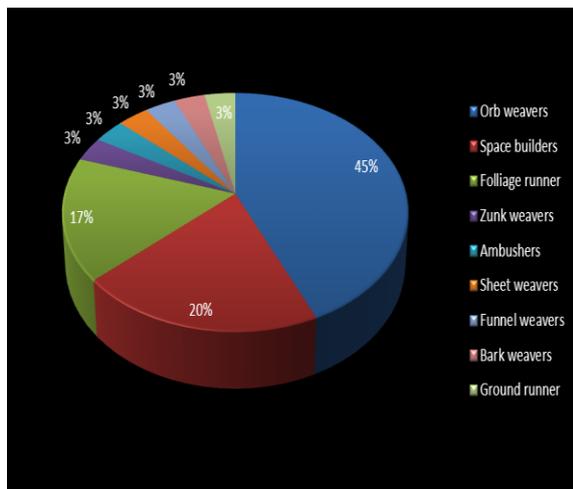
The spiders sampled belonged to 12 families and they were divided into eight functional groups (guilds) based on their foraging behavior in the field (Uetz et al., 1999). The most dominant guild was the orb weavers (45%) comprised of 13 species representing 5 families, among them family Araneidae representing 11 species, followed by Scytodidae, Theraposidae, representing 1 species each. The second dominant guild being space builders (20%) comprised of 6 species representing 2 families, among them the family Theridiidae representing 4 species, followed family Pholcidae representing 2 species respectively.

The foliage runners (17%) comprised of 5 species representing 2 families, among them the family Salticidae representing 3 species, followed by Oxyopidae representing 2 species respectively. The zunk weavers (3%) comprised of single species representing Pholcidae family, where other species of this family represents orb weavers. The ambushers (3%), sheet weavers (3%), funnel weavers (3%), bark weavers (3%) and ground runners (3%) each comprised of single species representing Pisauridae, Linyphiidae, Agelenidae, Hersiliidae and Sparassidae families respectively (Table 2, Fig. 2).

**Table 2.** List of spider species with common name and guild structure.

SL	Family	Species Name	Common Name	Guild Structures
1	Araneidae	<i>Argiope pulchella</i>	Garden cross spider	Orb weavers
2		<i>Gastercantha geminata</i>	Garden spiny spider	Orb weavers
3		<i>Argiope</i> spp.	Garden cross spider	Orb weavers
4		<i>Neoscona nautical</i>	Brown sailor spider	Orb weavers
5		<i>Neoscona mukerjei</i>	Common garden spider	Orb weavers
6		<i>Cyclosa</i> spp.	Grass jewel spider	Orb weavers
7		<i>Cyrtophora citricola</i>	Jungle tent weavers	Orb weavers
8		<i>Cyrtophora</i> spp.	Jungle tent spider	Orb weavers
9		<i>Nephila pilipes</i>	Giant wood spider	Orb weavers
10		<i>Herennia multipuncta</i>	Ornamental tree trunk spider	Orb weavers

SL	Family	Species Name	Common Name	Guild Structures
11		<i>Hypsosinga</i> spp.	Orb weave spider	Orb weavers
12		<i>Aelurillus</i> sp.	Small zebra jumper	Folliage runner
13	Salticidae	<i>Plexippus paykulli</i>	Small zebra jumper	Folliage runner
14		<i>Plexippus</i> spp.	Small zebra jumper	Folliage runner
15	Oxyopidae	<i>Oxyopes shweta</i>	Lynx spider	Folliage runner
16		<i>Oxyopes</i> spp.	Lynx spider	Folliage runner
17		<i>Pholcus fragillimus</i>	Pale daddy long leg spider	Space builders
18	Pholcidae	<i>Pholcidae</i> spp.	Daddy long leg/ vibrating/carpenter spider	Space builders
19		<i>Crossopriza lyoni</i>	Tailed cellar/tailed daddy long leg spider	Zunk weavers
20	Scytodidae	<i>Scytodes</i> spp.	Spitting spider	Orb weavers
21		<i>Theridion manjithar</i>	Tangle weavers	Space builders
22	Theridiidae	<i>Argyrodes</i> spp.	Dew drop spiders	Space builders
23		<i>Steatoda</i> sp.	Daimond comb footed spider	Space builders
24		<i>Achaearanea</i> sp	Brown widow spider	Space builders
25	Theraposidae	<i>Annandaliella travancorica</i>	Brazilian salmon tarantula	Orb weavers
26	Pisauridae	<i>Perenethis venusta</i>	Six spotted fishing spider	Ambushers
27	Linyphiidae	<i>Lepthyphantes</i> sp.	Money spider	Sheet weavers
28	Agelenidae	<i>Tegenaria domestica</i>	Domestic house spider	Funnel weavers
29	Hersiliidae	<i>Hersilia savignyi</i>	Two tailed spider	Bark weavers
30	Sparassidae	<i>Heteropoda venatoria</i>	Gaint crab/cane spider	Ground runner



**Fig. 2.** Composition of guild structure of spiders in percentage (%).

*Diversity variations of spider species in different locations of Chikmagalur taluk*

A total of 30 species representing 12 families were documented in all the three locations where study was conducted (Table 3). Among them 8 species from Muthodi, 6 species from Chikholale and 7 species from residential area were abundant, followed by 5 species from Muthodi, 4 species from Chikholale and 2 species from residential area were common, 5 species from Muthodi, 1 species from Chikholale were rare and species in residential area were rare. 2 species from Muthodi were very rare and no species from both Chikholale and residential area were documented (Table 3, Fig. 3).

**Table 3.** Status of spider species in coffee agroecosystem and residential area.

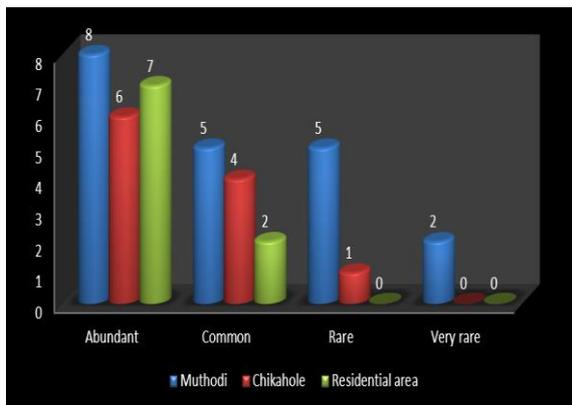
SL	Species Name	Family	Muthodi	Chikholale	Residential
1	<i>Argiope pulchella</i>		R	-	-
2	<i>Gastercantha geminata</i>		R	-	-
3	<i>Argiope</i> spp.		R	-	-
4	<i>Neoscona nautica</i>		A	A	-
5	<i>Neoscona mukerjei</i>		R	-	-
6	<i>Cyclosa</i> spp.	Araneidae	A	R	-
7	<i>Cyrtophoracitricola</i>		-	-	A
8	<i>Cyrtophora</i> spp.		-	-	A
9	<i>Nephila pilipes</i>		A	-	-
10	<i>Herennia multipuncta</i>		R	-	-
11	<i>Hypsosinga</i> spp.		C	C	-
12	<i>Aelurillus</i> sp.		A	A	A
13	<i>Plexippus paykulli</i>	Salticidae	A	-	A
14	<i>Plexippus</i> spp.		C	-	-
15	<i>Oxyopes shweta</i>	Oxyopidae	C	C	-
16	<i>Oxyopes</i> spp.		C	C	-
17	<i>Pholcus fragillimus</i>		A	-	-

SL	Species Name	Family	Muthodi	Chikholale	Residential
18	<i>Pholcidae</i> spp.	Pholcidae	A	C	-
19	<i>Crossopriza lyoni</i>		-	-	A
20	<i>Scytodes</i> spp.	Scytodidae	C	-	-
21	<i>Theridion manjithar</i>		A	A	-
22	<i>Argyrodes</i> spp.		-	A	-
23	<i>Steatoda</i> sp.	Theridiidae	-	A	-
24	<i>Achaearanea</i> sp		-	-	A
25	<i>Annandaliella travancorica</i>	Theraposidae	V	-	-
26	<i>Perenethis venusta</i>	Pisauridae	V	-	-
27	<i>Lepthyphantes</i> sp.	Linyphiidae	-	A	-
28	<i>Tegenaria domestica</i>	Agelenidae	-	-	C
29	<i>Hersilia savignyi</i>	Hersilidae	-	-	C
30	<i>Heteropoda venatoria</i>	Sparassidae	-	-	A

A: Abundant; C: Common; R: Rare; V: Very rare

**Table 4.** Diversity variations of spider species in different locations of Chikmagalur.

SL	Parameters	Muthodi	Chikholale	Residential area
1	Total spider diversity	20	11	9
2	Abundant	8	6	7
3	Common	5	4	2
4	Rare	5	1	0
5	Very rare	2	0	0



**Fig 4.** Diversity variations of spider species in different locations of Chikmagalur.

The result from the study data demonstrated the large degree variability between residential area and coffee agroecosystem. In the present study, the total collected individuals were 105, out of which only 30 species belonging to 12 families were identified and most of the individuals were yet to be identified.

It is also interesting to note that out of 60 families recorded in Indian region (Sebastian and Peter, 2009), out of which 12 families were recorded in the present study area. Spiders were only collected by hand-picking method, because to avoid any type of

disturbance in native ecosystem. Araneidae family was the most dominant among the collected families, which consists of 11 species. They are *Argiope pulchella*, *Gastercantha geminata*, *Argiope* spp., *Neoscona nautica* (Koch), *Neoscona mukerjei* (Tikader), *Cyclosa* spp., *Cyrtophora citricola*, *Cyrtophora* spp. *Nephil apilipes*, *Herenni amultipuncta*, *Hypsosinga* sp.,

The second dominant is the family Theridiidae, consisting of 4 species. They are *Theridion manjithar* (Tikader), *Argyrodes* spp., *Steatoda* sp. *Achaearanea* sp.

The family Pholcidae consisting of 3 species. They are *Pholcus fragillimus*, *Pholcidae* spp., *Cros soprizalyoni*. The family Saltididae consisting of 3 species and they are *Aelurillus* sp. (Karsch), *Plexippus paykulli*, *Plexippus* spp. The Oxyopidae having 2 species each which are and *Oxyopes shweta* (Thorell), *Oxyopes* spp. The remaining families Theraposidae, Pisauridae, Scytodidae, Agelenidae, Hersilidae, Linyphidae, Sparassidae and consisting of 1 species having *Annandaliellatra vancorica*, *Perenethis venusta*, *Scytodes* spp., *Tegenaria domestica* (Clerck), *Hersilia savignyi*, *Lepthyphantes* sp., *Heteropod avenatoria*, respectively.

It was observed that the distribution of species was most abundant in coffee agroecosystem than residential area, because coffee agroecosystem is a natural ecosystem where the environmental and surrounding disturbance is less when compared to that of residential area, which is the most disturbed area due to human interference.

The distribution of spider diversity is most abundant in Muthodi coffee agroecosystem than Chikhohale, because Chikhohale is present in area connected with city and the coffee cultivated was Arabica and whereas Muthodi is far away from city and most of the Muthodi region is connected with forest area, and the cultivated coffee is Robusta. It can also be considered that a great variety of spiders can exist in this area due to rich ecosystem in Western Ghats Area.

Spiders generally have humidity and temperature preferences, which limit them to areas within the range of their “physiological tolerances” which make them ideal candidates for land conservation studies (Richert, 1986). Therefore, documenting spider diversity patterns in this ecosystem can provide important information to justify the conservation of ecosystem.

### Summary

India is rich in spider diversity; Chikmagalur also exhibits good number of spiders and remarkable diversity in spider fauna. Spiders are abundant in diverse and with over 45,000 recognized species. Spiders are multifunctional in nature their webs have high levels of strength and toughness so spider webs are indicated as “Nature of Engineering”. Survey was conducted for Six months in the mid Westernghats region of Karnataka (January to June) A total of 105 individuals representing 12 families and 30 species were recorded from three different habitats. The coffee agro ecosystem is rich in diversity of spiders than residential area due to its rich floral diversity. The area is rich in spider diversity it requires the continuous long study nevertheless present study serves as the baseline for further study of spiders in Chikmagalur area.

### Conflict of interest

We authors do not have conflict of interest.

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